Combining Machine Learning and Knowledge Engineering

Knut Hinkelmann

Challenges for Data Driven Solutions

- Consistency of Past and Future
- Cold Start/ New Products
- Explanations
- Compliance

A Temporal View

Observe the Past

Predict the Future

Data

Decision

Time

Consistency of Past and Future

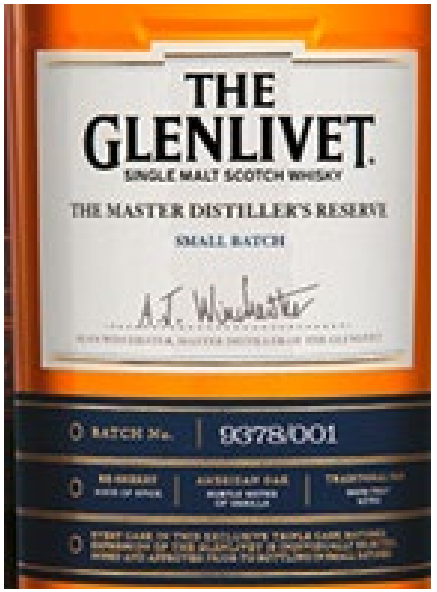
Example: Changes in Customer Behaviour because of climate change and Pandemic

Cold Start: New or Limited Products

Limited Editions

Single Cask

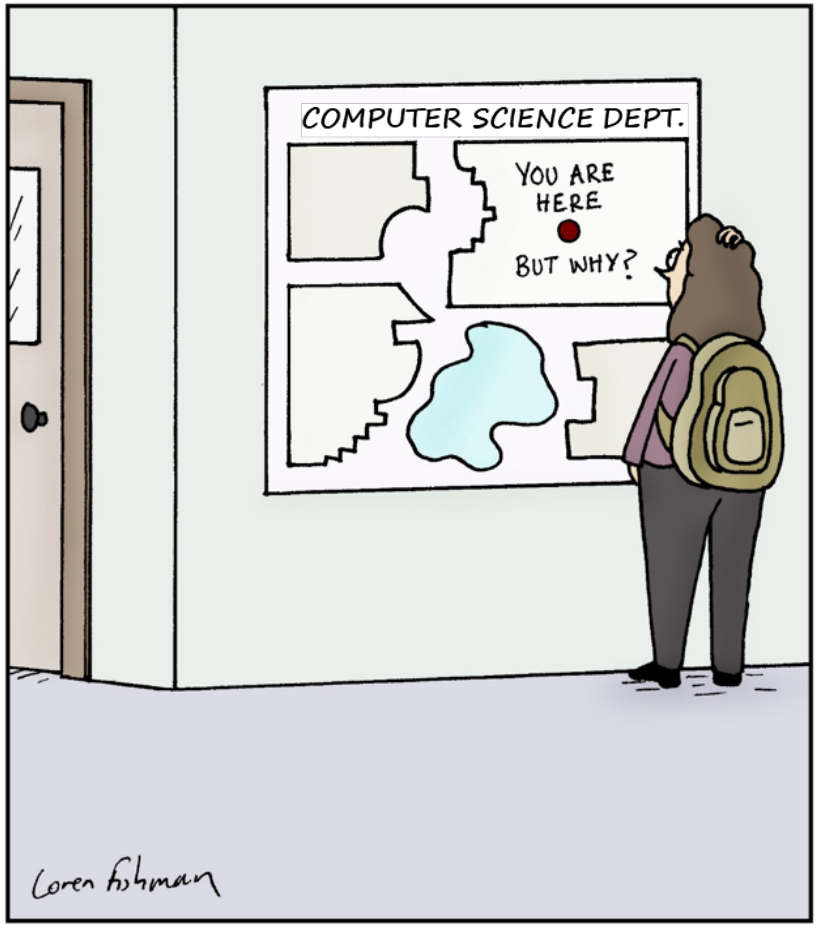
Small Batch



New Distilleries/Brands

Explanations

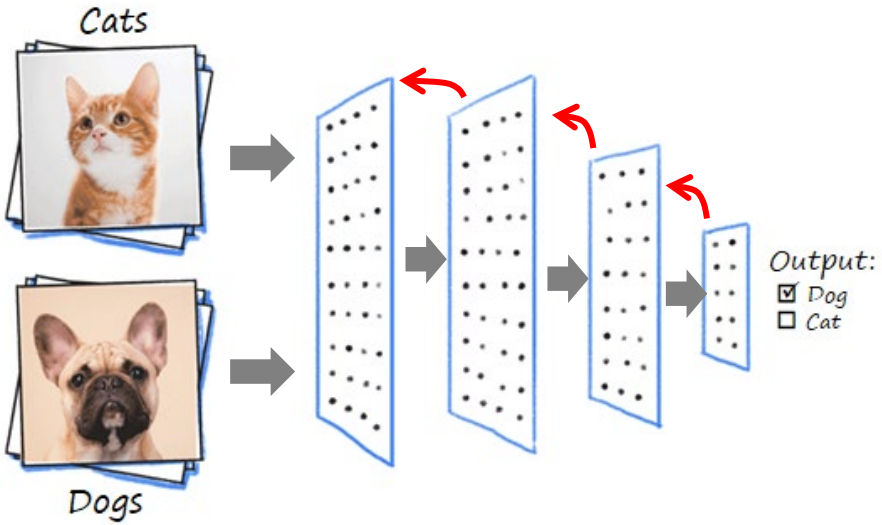
Can decisions without explanation be intelligent?



Trust
Compliance
Traceability

In particular for subsymbolic learning (neural networks)

AI Systems are Highly Specialized for one Problem

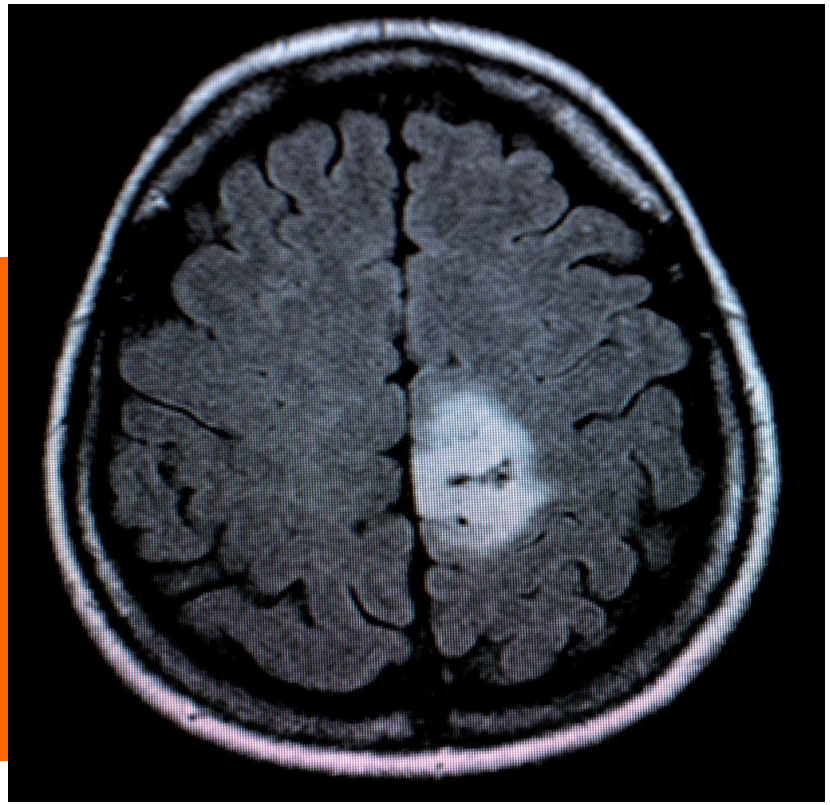


Dog or Cat?
→ Wolf

The system does not have the concept of a wolf

Photo by Marc-Olivier Jodoin on Unsplash

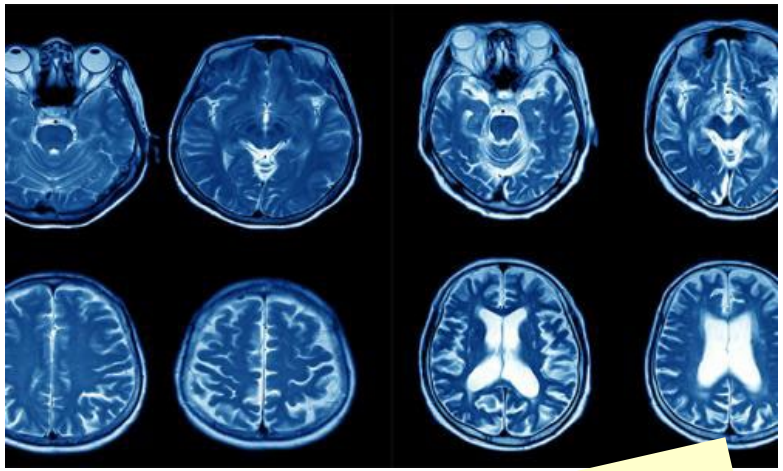
Diagnosis



Therapy

Would you trust your physician, if she cannot explain, why she recommends a surgery?

AI Systems are Highly Specialized for one Problem



Recognizes only cancer

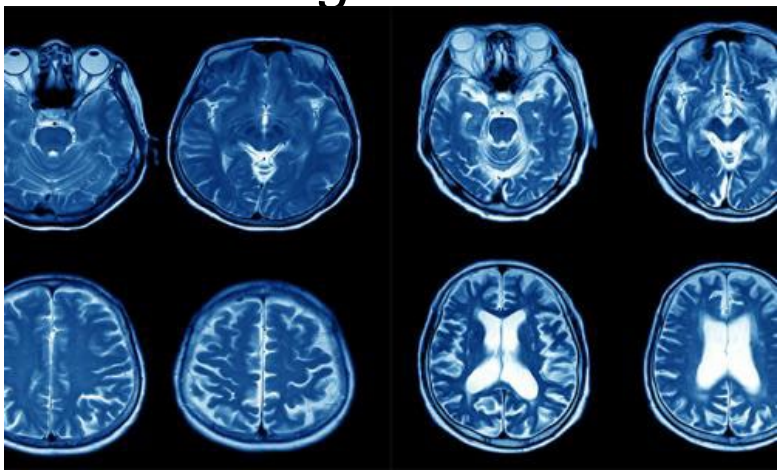
Has broad knowledge

Bild von Anh Nguyễn Duy auf Pixabay

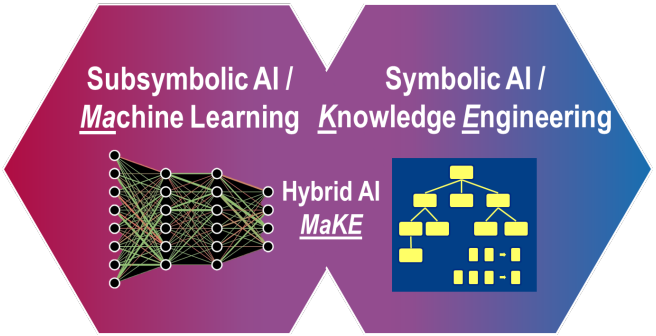
https://www.netz.de/trends/news/artikel-gewebeanalyse-googles-ai-erkennt-krebs-zuverlaessiger-als-der-arzt

Combining Machine Learning with Knowledge

Diagnosis



Therapy



Data Processing

Domain Knowledge
(human or knowledge base)

Combining Machine Learning with Knowledge Engineering

Example: Autonomous Driving

- Machine Learning:
  Driving Behaviour

- Knowledge Engineering:
  Traffic Rules

Combining Machine Learning with Knowledge Engineering

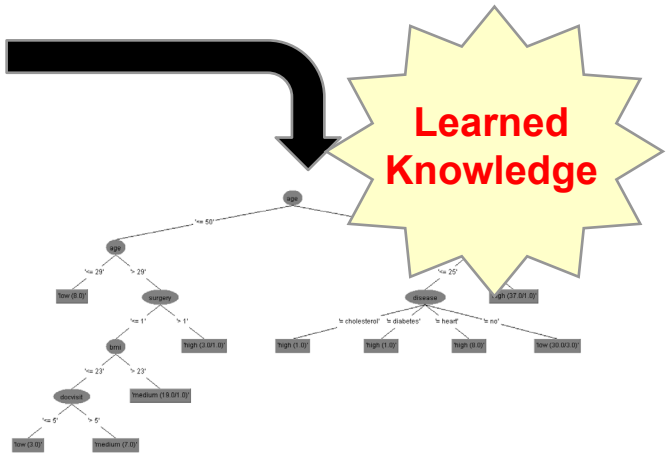
Example: Eligibility Decision for Insurance

Accept yes/no

Combining Machine Learning and Knowledge Engineering for Eligibility Decisions (1/2)

- Example: Application of health insurance
  - Machine Learning: data records about risks of clients

Age	surgery	docvisit	allergy	med	disieases	bmi	class
20	0	2	no	no	cholesterol	28	low
21	0	4	no	no	no	23	low
49	2	12	yes	yes	heart	34	high
22	0	3	no	no	no	23	low
51	2	2	yes	yes	diabetes	26	high
52	2	8	no	no	heart	31	high
52	0	3	yes	no	no	22	low
52	2	12	yes	yes	diabetes	27	high
52	0	11	yes	no	cholesterol	29	high
23	0	3	no	no	no	23	low



  - Engineered knowledge: eligibility and compliance

Applicants from Switzerland are eligible.
A person younger than 21 year is not able to apply
…

Engineered Knowledge

Combining Machine Learning and Knowledge Engineering for Eligibility Decisions (2/2)

Examples of learned rules:

```
risk (Person, high) :-      age(Person,A), A > 50,
                            bmi(Person, Bmi), Bmi =<25,
                            disease(Person, diabetes).
risk (Person, low) :-       age(Person,A), A =< 29.
```

Learned Knowledge

Examples of engineered rules:

```
eligible(Person, no) :-     age(Person,A), A =< 21.
eligible(Person,no) :-      country(Person,C), C =/= switzerland.
```

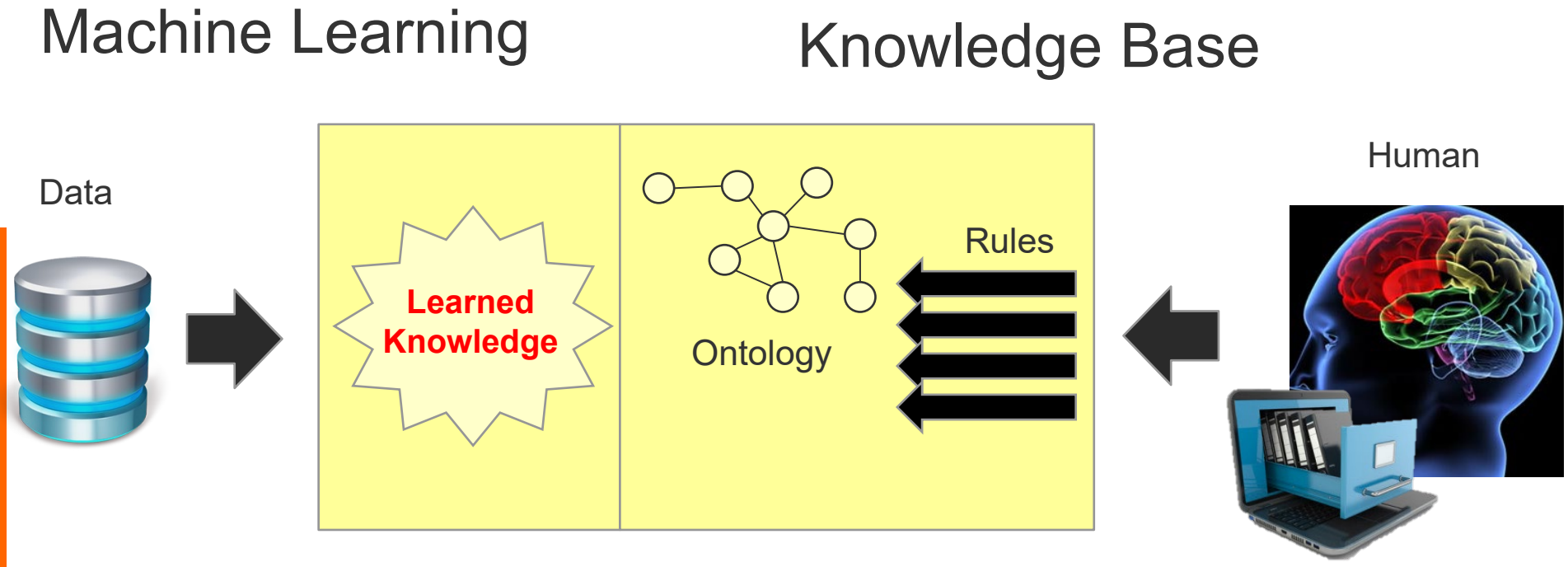
Engineered Knowledge

Combining engineered and learned rules:

```
accept(Person, yes) :- eligible(Person, yes), risk(Person, low).
accept(Person, yes) :- eligible(Person, yes), risk(Person, medium).
accept(Person, no) :- eligible(Person, no).
accept(Person, no) :- risk(Person, high)
```

Engineered Knowledge

Combining Machine Learning and Knowledge Base



- Tacit or unknown knowledge
- Stable knowledge

- Knowledge we are aware of
- Knowledge that must be correct
- Explanations

Summary: Creating Knowledge Bases

- **Knowledge Engineering:** Human experts build knowledge base
  - For knowledge we are aware of
  - For knowledge that must be correct (e.g. compliance rules)
  - Inferences are explainable (trust)

- **Machine Learning:** automatic creation of knowledge from example data
  - Can solve complex tasks for which
    - knowledge is not known
    - knowledge is tacit
  - For stable world, where future can be predicted from past
  - Reliance on real-world data instead of pure intuition
  - Requires large sets of data